ATTACHMENT B

BORROW ANALYSIS

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BORROW AREA ANALYSIS
JAMES ISLAND

1. Introduction. Analyses of potential borrow areas for James Island were performed to assess the quantity and quality of borrow sand for the subject project. E2CR initially developed eight borrow areas associated with the different alignments being considered during the reconnaissance phase of the project conducted by the Maryland Port Administration. Information about these borrow areas was obtained from subsurface investigations and laboratory testing performed for the 2002 Reconnaissance Study. Analysis of these borrow sources supported the engineering screening performed as part of the Feasibility Plan Formulation process.

The Plan Formulation identified the initial James Alignment 5 as the preferred location for the James Island site. The next phase of borrow analysis focused on the potential borrow sources located within the preferred location. This analysis considered all of the previous subsurface investigations and the information obtained from 61 new borings performed in the study area defined in the Plan Formulation phase of this study.

2. Phase 1 Borrow Analysis. E2CR identified eight potential borrow areas to supply sand needed for construction of the containment dikes in the 2002 Reconnaissance Report. The areas consist of a total of approximately 920 acres and contain silty, fine sand materials that are similar to those materials used to construct the existing containment dikes at Poplar Island. The areas include sand deposits ranging from a minimum of 4 to near 18 feet in average thickness. The deposits include some interbedded fine-grained silt and clay materials. Some portions of the sand borrow deposits may be overlain by a layer of fine-grained silt or clay that must be removed to expose the usable sand deposits.

2.1 Borrow Quantity Evaluation. Throughout the plan formulation process, rough quantity estimates were prepared for the various alternate alignments for James Island. Table 2-1 provides an analysis of the borrow materials available in comparison to the borrow quantities required to construct each of the five alignment alternatives. The analysis used the portion of the borrow area within the footprint of the alignment. The quantity of borrow material that would be obtained from the excavation of a required access channel is included in the estimate of available borrow material. The borrow available was compared to the borrow required. Based on history at the current Poplar Island project, to account for dredging losses during hydraulic dredging, inefficiencies in the mechanical recovery of the stockpiled borrow materials, and uncertainties due to lack of full subsurface exploration data, a borrow available-to-borrow required factor of 2.0 was the goal for each alignment in the evaluation. The initial borrow available-to-required factor at Poplar Island was 1.5. This has proven to be inadequate due to the difficulties in obtaining adequate amounts of sand for the continuing requirements of the project.

To meet the 2.0 ratio for creating uplands to +20 MLLW, Alignments 1 through 5 all require borrow materials in excess of the quantity available within the project footprint and the required access channel excavation. As shown on Table 2-1, the only alignment with a

very low ratio is Alignment 1. The remaining alignments all have ratios above 1.5, and would be considered to have marginally acceptable amounts of borrow within the project footprint.

Table 2-1. Initial Borrow Quantity Analysis

Alignment	Borrow Quantity Available (MCY)		Borrow Quantity Required (MCY) +10' Uplands	Borrow Quantity Required (MCY) +20' Uplands	Borrow Available-to-Required Ratio for +10 Uplands	Borrow Available-to-Required Ratio for +20 Uplands
1	0.55					
1	1.37					
	Alignment 1 Total	**1.93**	**2.71**	**4.77**	**0.99**	**0.56**
2	8.62					
2	5.54					
	Alignment 2 Total	**14.17**	**4.63**	**7.99**	**3.22**	**1.87**
3	8.44					
3	2.35					
	Alignment 3 Total	**10.79**	**4.03**	**6.97**	**2.86**	**1.66**
4	7.49					
4	5.53					
	Alignment 4 Total	**13.03**	**4.42**	**7.65**	**3.12**	**1.80**
5	7.49					
5	5.53					
	Alignment 5 Total	**13.03**	**4.25**	**7.39**	**3.24**	**1.86**
Access Channel	0.75	**0.75**				

*Available Borrow Quantities Estimated Based on Reconnaissance Borings Performed by E2CR

3. Phase II Borrow Analysis. The plan formulation screening process selected an alignment very similar to James Alignment 5. Subsurface investigations focused on foundation and borrow conditions for this alignment. The feasibility phase of investigations consisted of 61 additional borings within the proposed alignment. Laboratory testing was performed on selected samples to assess the quality of the material for borrow purposes.

For reasons described later in this attachment, it has been determined that it is not desirable to borrow sand from beneath wetland cells. It is also environmentally desirable to keep borrow materials within the overall site footprint, to reduce environmental impacts. While the recommended plan was similar to the James 5 alignment analyzed by E2CR, the siting of the upland and wetland cells changed. Instead of a wetlands east-and an uplands west site, the uplands were sited at the north, with the wetland sited at the southern portions of

the proposed alignment. This resulted in the elimination of four of the borrow areas identified by E2CR due to their location within the new footprint of the wetlands. The additional borings performed by Baltimore District further defined the borrow extents in the uplands. The borings performed within and around the proposed upland area defined a large sand deposit ranging in surficial thickness from 4.5 to more than 36.5 feet. In some borings, a thin (2.5-5ft thick) layer of silt and/or clay was found below the surficial sand. Beneath the silt/clay layer, additional sand was found. See Table 3-1 for a detailed assessment of the Baltimore District borings.

3.1 Revised Borrow Area Limits. The revised borrow area limits are contained within the uplands footprint and the proposed access channel alignment. The thickest deposit is located in the central portion of the upland area. The thickness of sand in this area is generally between 15 and 25 feet. The sand diminishes in thickness as it extends to the east and west where it is less than 10 feet thick in some locations. The sand thickness along the access channel alignment extends to a depth of 25 feet below the mudline.

3.2 Borrow Excavations. Borrow materials obtained from within the project footprint will be limited to that quantity which can be excavated from within the proposed upland cells of the project to the maximum extent practicable. During the construction of the current Poplar island project, most of the required borrow materials were obtained from locations within wetland cells 3, 4, and 5. The deep depressions left in those cells significantly increases the thickness of dredged material and results in a wide variation in dredged material thickness within the cells. The consequential large magnitudes of settlement and differential in settlement due to the dredged material consolidation make it extremely difficult to achieve the very narrow target elevations required for wetland plants. Therefore, borrow sites will be excluded from wetland cells to the maximum extent possible. If after further analysis, it becomes unavoidable to borrow within the wetlands, a wetland cell or two will be designated as a borrow location. That area will be borrowed as thinly and uniformly as possible to limit the settlement issues stated above. Final cell development may result in ponds or mudflats which can be offset in the other cells under the Adaptive Management Plan.

3.3 Borrow Quantity. After accounting for the upland dike and crossdike footprints, and the required 100 foot setback from the perimeter dike toe, the remaining borrow sand was estimated using a GIS analysis. The only sand considered in the analysis was sand from the surface down. No sand below clay or silt seams was considered at this stage. The sand thickness at each boring location was input, with the GIS then calculating total available borrow within the upland cells. This area would yield an estimated 14.45 million cubic yards (mcy) of sand for construction of the project. The access channel is estimated to provide approximately 1.48 mcy of sand as well. See figure 3-1 for surficial sand deposit information. The updated sand quantity required for dike construction was estimated at 8.55 mcy. That borrow quantity is approximately 1.86 times the estimated quantity of material needed for dike construction and is considered marginally sufficient to satisfy the project needs.

Having a ratio of below 2.0 does not mean that there is insufficient borrow available. However, it shows that there is a risk of a borrow shortage at the site. To reduce this risk, additional sand sources were investigated. Several of the borings, particularly in the southwest to central portion of the upland, showed a thin, 2.5-5.0 foot thick clay/silt zone between the surficial deposit and a deeper sand deposit. The lower sand deposit is estimated at having between 2.5 and 3.5 mcy available. Even using the lower estimate of 2.5 mcy will push the ratio above 2.0 to 2.16. The additional subsurface investigations which will be undertaken during the next design phase will help to reduce the current uncertainties with regard to borrow quantities available.

3.4 Borrow Material Quality. The quality of the borrow material within the borrow site is primarily defined by the percentage of quantity of fines within the sand. Fines are the silt and clay size portion of the borrow materials. A significant portion of these fine materials, and some of the fine sand fraction, will be washed away when the sand is dredged for use in dike construction. While that loss of fines improves the engineering properties of the sand, it reduces the quantity available for construction. It is generally estimated that 15 to 25 percent of the quantity excavated by dredging will be lost. As the percentage of fines at the borrow source increases, the percentage lost in the dredging process also increases. A lower fines content at the borrow source will result in a lower fines content in the sand placed in the dike section. It is desirable to maintain the fines content in the dike fill below 30% to assure that the material properties are dominated by the sand fraction rather than the weaker and less permeable clay and silt materials.

A total of 206 gradation tests were performed on samples from the borings collected from the study area. While not all of the sands tested will end up within the borrow limits, the gradation tests for sands are indicative of the quality of the materials that will be used for dike construction. The surficial sands in the borrow areas within the upland areas contain an average of approximately 16.4% fines (percentage by weight passing a standard No. 200 sieve). The actual fines content ranged from a low of 0 % to a high approaching 50% fines. Most of the samples were in the 10% to 20% fines range. Therefore, this sand deposit is an excellent source of materials with respect to quality of material for dike construction.

Since this deposit has a low average fines content, the percentage lost can be expected to remain near the low end of the typical 15 to 25 percent range. Due to the low average fines content in this deposit, the resulting fill properties can be expected to be excellent with limited pockets of marginal material.

Table 3-1. Assessment of Borrow Material from Borings.

Boring	Location (Upland/Wetland/ Channel)	Depth of Sand from Surface (ft)	Silt/Clay Layer Thickness (ft)	Additional Sand Thickness (ft)	In Selected Borrow Area (Yes/No)
JB-101	Upland	9.5	NA	NA	No
JB-102	Upland	22.4	12.1	7+	Yes
JB-103	Upland	19.9	NA	NA	Yes
JB-104	Upland	15	4.5	7.5	Yes
JB-105	Upland	14.5	7.5	8	Yes
JB-106	Upland	24.5	NA	NA	No*
JB-107	Upland	29.5	NA	NA	Yes
JB-108	Offsite	26.5+	NA	NA	No
JB-109	Upland	14.5	7.5	4.5+	Yes
JB-110	Upland	7	5	14.5+	Yes
JB-111	Upland	26.5+	NA	NA	Yes
JB-112	Upland	12.5	2.5	11.5+	Yes
JB-113	Wetland	7.5	4.5	14.5+	No
JB-114	Wetland	7	NA	NA	No
JB-115	Wetland	12	2.5	5	No
JB-116	Wetland	2	NA	NA	No
JB-117	Wetland	2	NA	NA	No
JB-118	Wetland	4.5	2.5	12.5	No
JB-119	Wetland	2	NA	NA	No
JB-120	Wetland	7	5	14.5+	No
JB-121	Wetland	7	5	5	No
JB-122	Wetland	0	NA	NA	No
JB-123	Offsite	2	NA	NA	No
JB-126	Offsite	2	8.8	13.7	No
JB-127	Offsite	4.5	2.5	12.5	No
JB-128	Offsite	4.5	5	17+	No
JB-129	Wetland	2	7.5	17+	No
JB-130	Offsite	4.5	5	22.5	No
JB-131	Upland	9.5	NA	NA	Yes
JB-201	Upland	32	NA	NA	Yes
JB-202	Offsite	14.5	NA	NA	No*
JB-203	Upland	0	4.5	17.5	Yes
JB-204	Offsite	4.5	NA	NA	No*
JB-205	Offsite	36.5+	NA	NA	No*
JB-206	Upland	22	NA	NA	Yes
JB-207	Offsite	19.5	NA	NA	No*
JB-208	Upland	22	NA	NA	Yes
JB-209	Upland	9.5	2.5	5	Yes
JB-210	Upland	22	2.5	10	Yes
JB-211	Wetland	9.5	2.5	10	No
JB-212	Wetland	9.5	2.5	5	No

Boring	Location (Upland/Wetland/ Channel)	Depth of Sand from Surface (ft)	Silt/Clay Layer Thickness (ft)	Additional Sand Thickness (ft)	In Selected Borrow Area (Yes/No)
JB-213	Upland	17	5	4.5+	Yes
JB-214	Wetland	2	NA	NA	No
JB-215	Wetland	0	NA	NA	No
JB-216	Wetland	7	NA	NA	No
JB-217	Wetland	2	10	14.5+	No
JB-218	Wetland	4.5	NA	NA	No
JB-219	Wetland	2	5	13.8	No
JB-220	Wetland	0	NA	NA	No
JB-221	Wetland	7	2.5	17+	No
JB-222	Wetland	4.5	NA	NA	No
JB-223	Upland	9.5	2.5	17+	No
JB-224	Upland	9.5	2.5	17+	Yes
JB-225	Upland	7	5	3.8	Yes
JB-226	Upland	15.8	2.5	8.2+	Yes
JB-227	Offsite	24.5	NA	NA	No*
JB-228	Upland	9.5	5	12+	Yes
JB-229	Wetland	2	NA	NA	No
JB-230	Channel	17	NA	NA	Yes
JB-231	Channel	2	NA	NA	No
JB-232	Channel	26.5+	NA	NA	Yes
JB-233	Channel	26.5+	NA	NA	Yes

*Just Offsite from the Borrow Area--Depths averaged in GIS Analysis for Borrow Quantities
Highlighted Borings Used in Determining Borrow Quantities

REFERENCES

E2CR, Inc., *Geotechnical Reconnaissance Study for James Island, Chesapeake Bay, Maryland*, prepared for Gahagan & Bryant Associates, Inc., August 2002.

Maryland Environmental Service, Gahagan & Bryant Associates, Inc., Moffat and Nichol Engineers, Maryland Geological Survey, *Conceptual Report: James Island Beneficial Use of Dredged Material*, prepared for Maryland Port Administration, November 2002.

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